Assessing the Safety of Existing Roads: A More Objective Methodology

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ABSTRACT

Safety Audits of Existing Roads (SAER) are independent and expert reviews of a Road Controlling Authority's (RCAs) provision of a safe travel environment. Recently there has been increasing interest in SAER as many RCAs seek to monitor and improve service delivery. While many RCAs see SAER as a tool, which assists them in their own business, the potential exists for SAER to also monitor service provision between regions and over time. However, experience over the last 5 years has highlighted the subjective nature of the process and inconsistencies between the safety issues identified, the assessment of impact severity of these issues, and the relationship between the safety issues identified and known accident causation.

To address these issues a more quantitative method of assessment is being developed. This new method, described as Road Infrastructure Safety Assessment (RISA), involves comparing a route with a baseline road type and recording differences in infrastructure items for which there are known accident relationships. Two indicators of safety result from this comparison: Risk and Score. Risk is independent of traffic volume, terrain, and road type effects. It measures the relative risk on the assessed road compared to a baseline road of that type. This is a measure of how well the RCA is managing its particular road assets from a safety perspective. To allow comparative measures to be made across road types and RCAs, the Risk indicator is scaled to reflect the route context. Score is the Risk indicator scaled by factors for road type, terrain, and traffic volume.

Several field trials on low volume rural roads have tested the practicability of RISA. The indicators have been compared with accident rates and assessor subjective ratings of the routes assessed. The comparisons show that RISA relates more strongly to the accident history than the purely subjective assessor rating. At this early stage, the sampling process is not refined to ensure that the sample is reflective of a RCA road network, and that the number of routes assessed is enough to be able to generate a 'score' for an entire RCA road network. This means that route scores cannot yet be combined, allowing for comparisons between RCA road networks.

1 INTRODUCTION

Safety Audits of Existing Roads (SAER) were developed to formally assess the safety of existing road corridors. In 1995[1] Transit New Zealand (Transit) began trialling procedures for undertaking audits of existing road networks, based on a method developed by the New South Wales Roads and Traffic Authority. Transfund New Zealand (Transfund) continued to develop this process, resulting in the current procedures used for SAER[2]. To date, Transfund has undertaken SAER within 33 Road Controlling Authorities (RCAs) around New Zealand.

SAER involve a team of independent experts driving a sample of a RCA's urban and rural road network. This team provides a commentary on the road infrastructure themes such as alignment consistency and surface. The strategies identified solely concern the physical aspects of road infrastructure. As a procedure, SAER provide an independent and expert review of a RCA's provision of a safe travel environment.

[1] Transit NZ, *Safety Audits of Existing Roads: Review of Process Development and Initial Implementation,* Report No. 95/434S, Wellington, Feb 1996.
[2] Transfund NZ, *Safety Audit Procedures for Existing Roads,* Report No. RA97/623S, Wellington, Dec 1998.

An SAER provides feedback to a RCA on both the things the RCA does well and those areas that may require additional attention.

There has been increasing interest in SAER as many RCAs seek to monitor and improve service delivery. While many RCAs see SAER as a tool that assists them in their own business, there is also a growing realisation that SAER may be used as a means of monitoring service provision nationally and over time.

Over the introductory period, the commissioning and funding of the SAER has remained solely with Transfund. With the resources currently available it is only possible for Transfund to undertake a limited number of SAER each year. At the current rate it could take 15 years or more before a single audit has been undertaken in every RCA. Clearly this situation is less than adequate and does not realise the full potential of this safety management system.

In addition to these implementation issues there was a concern regarding the essentially subjective assessment of SAER. The SAER database, which records the items identified, reveals that the most commonly identified items are generally not related to the type of road assessed. For example, when assessing a windy road through mountainous terrain the items that compose the road, poor geometry and grade, were not identified. Rather items such as vegetation control and curve warning signs were identified.

2 RISA DEVELOPMENT

Road Infrastructure Safety Assessment (RISA) is a progression of SAER, developed initially for rural road application. The purpose of RISA is to provide a rating method to improve the systematic quantification of the safety impacts associated with items identified during an assessment. By using a quantitative rating method, the nation's roads can be assessed with a greater degree of objectivity.

The objectives of RISA are:

- To provide a more objective assessment of the safety of existing roads;
- To identify infrastructure items for which there is known accident causation;
- To assess existing roads on the basis of risk to the road user; and
- To provide a system that does not require excessive field data collection, and which is easy to use in the field.

This section of this paper is set out in a similar fashion to the steps undertaken during a RISA. The steps are:

1. Decide on route sample
2. For each route determine baseline road type
3. Field process to develop relative risk for infrastructure items

These three steps develop a Risk reflecting the safety provision of the asset. The mathematical basis for Risk is then described. To measure overall safety provision Risk is adjusted for road context by the following factors:

- Road Type;

- Traffic Volume;
- Terrain; and
- Intersection Type (if considering intersections)

2.1 SAMPLE SELECTION

The RCA rural road network is analysed in terms of road type and the RCA's own classification system. Rural routes of five kilometres, with 100-km/h speed limits are then selected. At this early stage, the selection process is not refined to ensure that the sample is reflective of a RCA road network, and that the number of sections assessed is enough to be able to generate a 'score' for an entire RCA road network. This means that route scores cannot yet be combined, which would allow for comparisons between RCA road networks.

2.2 ROAD TYPE BASELINE

In order to compare the safety for different routes, a baseline from which to measure accident rate changes was required. Relationships described in section 2.5 were used to define the baseline characteristics shown in Table 1. The traffic volume on the route determines the appropriate baseline.

Table 1 Baselines for RISA

Baseline Number	Baseline	Traffic Volume (vehicles/day)	Lane Width	Shoulder Width
1	Low Volume Rural	0-1000	3.5m	0.0m
2	Medium Volume Rural	1000-4000	3.5m	0.75m
3	High Volume Rural	Over 4000	3.5m	1.5m

2.3 FIELD ASSESSMENT

The field process of RISA is similar to SAER following these steps:

1. Determine road lane and shoulder widths for road type. Check these widths on the route.
2. Drive over mid-block section once in both directions at 'normal' driving speed assessing those elements that are only appreciated at this speed, e.g. context of curves.
3. Drive over mid-block section once in both directions at slower driving speed (40-60km/h) assessing detailed items such as hazards in the clear zone.
4. Categorise the route terrain into flat, rolling, or mountainous.
5. Assess intersections on the route.
6. Subjectively assess the safety provision of the entire route. This is included as a sanity check on the RISA indicators.

The road to be assessed is, if necessary, divided into homogenous sections based on traffic volumes and terrain. The intersections are identified separately. Field sheets similar to that presented in Figure 1 are completed for eachroute . There are four sheets in total, one for each of the mid-block themes, and one for intersections:

- Cross Section;

- Alignment;
- Surface and Miscellaneous; and
- Intersection.

Audit Name	Your Name	Date	Road Name	Terrain	AADT	Length	Rd Type	RISK
A District	*Safety Assessor*	*6/6/03*	*Deep Drain Rd*	*Flat*	*650*	*4km*	*1*	1.203

CROSS SECTION	Item	0 km — 1km — 2km — 3km — 4km	Exposure Length (km)	Relative Risk	Risk Score
	One Lane Bridge w/warning (BEM)		*1*	60	60
	One Lane Bridge w/out warning			80	0
Hazards within 6m	Point			20	0
Hazards within 6m	Recoverable length			10	0
Hazards within 6m	Non-recoverable length		*1.5*	15	11.25
	Unsealed Shoulder			5	0
Shoulder width	Very wide (only Road Type 1)			-20	0
Shoulder width	Wide (only Road Types 1,2)			-10	0
Shoulder width	Narrow (only Rd Types 2-6)			10	0
Shoulder width	Very narrow (only RTs 3-6)			20	0
Lane width	Narrow		*1*	10	5
Lane width	Very narrow			20	0
Lane width	Very narrow			20	0
Lane width	Narrow		*1*	10	5
Shoulder width	Very narrow (only RTs 3-6)			20	0
Shoulder width	Narrow (only Rd Types 2-6)			10	0
Shoulder width	Wide (only Road Types 1,2)			-10	0
Shoulder width	Very wide (only Road Type 1)			-20	0
	Unsealed Shoulder			5	0
Hazards within 6m	Non-recoverable length			15	0
Hazards within 6m	Recoverable length			10	0
Hazards within 6m	Point			20	0
		4km — 3km — 2km — 1km — 0 km		Sheet Total	81.25

Figure 1 RISA Field Sheet

For each route, the Team will identify items on the route and record the road length of the items onto the field sheets. These items are relative to the baseline road type.

The completed field sheet in Figure 1 is for cross section items. It was completed in the field by checking the route for any of the items on the sheet. Where the items were present, the distance the item occurred for was recorded as a line on the appropriate row for the relevant distance. In this case only three of the cross section items were applicable. After the section had been driven over, the length for each item was then scribed into the exposure length column. The sheet is set out like a plan for the road, the thick black line being the centreline, dividing one side of the road from the other.

2.4 RISA FORMULA

To remove some of the subjectivity of SAER, RISA employs data from accident studies. Relative risk factors for each deficiency or improvement have then been determined on the basis of existing literature. However, in some cases it has not been possible to quantify the impacts, and an estimated value of relative risk has been made. A recent Transfund report[3] details how the relative risk factors were developed.

The following formula describes how risks are developed for infrastructure items:

*Risk Score = Relative Risk * Exposure*

[3] Transfund NZ, *Safety Audits of Existing Roads: Developing a Less Subjective Assessment,* Report No. OG/0306/24S, Wellington, Sep 2003.

Relative Risk is the percentage accident rate difference identified for the infrastructure item multiplied by 100. Items with negative relative risks improve the safety of a road beyond the road type baseline.

Exposure is the proportion of the audit section affected by the infrastructure item, measured in kilometres, or in some cases the number of occurrences of an item.

As a measure of safety performance for a route, RISA sums the risk scores for all items. This sum is expressed as a risk per kilometre, equivalent to the accident rate, by dividing the sum of the risk scores by 100 and by the route length (usually five kilometres) and added to one. An example calculation is shown in part in Figure 1. This typical field sheet describes the assessment of cross section items. Most of the items on the field sheet in appear twice. This is for each direction of travel. For these items the risk score is divided by two, as for item 'Lane Width Narrow'. For uni-directional items this does not apply (the item for one lane bridge is an example of this). At this stage the possible increase or decrease in risk resulting from a combination of items has not been considered.

Item risk scores are summed for each field sheet. Using Figure 1 as an example, the risk score for cross section items is 81.25 for the 4 km route. To compare routes it is necessary to divide the risk score by the route length being assessed to get a risk per kilometre:

$$\frac{RiskScore}{SectionLength} = \frac{81.25}{4} = 20.3$$

The risk per kilometre is expressed relative to 1.0:

$$= 1 + \frac{20.3}{100}$$

= 1.203

This value is the cross section risk and is displayed in the top right hand corner of Figure 1. Using this approach, a road that has the same characteristics as the baseline will have a risk of 1.0. In this example the road has a 20.3% higher risk rate per kilometre for cross section items than the baseline. Similar field sheets for alignment, and surface items are completed in the same way. The risks per kilometre are summed for the three field sheets to get a Mid-Block Risk. The intersection items are assessed in a similar way to get an Intersection Risk.

The Mid-Block Risk is a measure of safety performance for the asset. To develop an overall measure of safety it is necessary to incorporate factors for road type, volume, and terrain, which are described in the next section. This is termed the Mid-Block Score and represents the risk to the road user. To illustrate consider the above example. Assuming the alignment and surface risks are 1.1 and 0.9 respectively, the Mid-Block Risk is 1.203. The terrain is flat and the traffic volume is 650 vehicles per day. Using Table 3, the road type is 'low volume rural' and the road type factor is 1.6. Using Table 5, the terrain factor is 1.0. Finally the traffic volume factor is the traffic volume divided by 100. Table 2 details the Mid-Block Score calculation.

Table 2 Example calculation of Mid-Block Score

Mid-Block Risk (MR)	Factors			Mid-Block Score (=MR*R*T*V)
	Road Type (R)	Terrain (T)	Volume (V)	
1.203	1.70	1.00	0.65	1.33

2.5 ROAD TYPE FACTOR

In order to compare the safety for different routes, a baseline from which to measure accident rate changes was required. The Transit NZ Control Manual[4] (the Manual) provides typical non-intersection accident rates for roads of varying sealed lane and shoulder width. The rates were calculated using New Zealand average accident rates, and concur with rates in the Project Evaluation Manual[5], and the Geometric Design Manual[6]. Also, a degree of concurrence was found with actual accident rates the Land Transport Safety Authority (LTSA) observed for their road types. The Manual rates were used and aggregated into three road types for rural roads as shown in Table 3.

Table 3 Road Type Factor

Road Type Number	Road Type	Traffic Volume (vehicles/day)	Lane Width	Shoulder Width	Road Type Factor (dimensionless)
1	Low Volume Rural	0-1000	3.5m	0.0m	1.7
2	Medium Volume Rural	1000-4000	3.5m	0.75m	1.6
3	High Volume Rural	Over 4000	3.5m	1.5m	1.0

The Manual rates are national averages, and represent the New Zealand average accident rates for roads with constant lane and shoulder width. As such they encompass roads that, for example have varying traffic volume, terrain, alignment, hazards, and delineation. Further, the Manual rates may be traffic volume dependent; as the traffic volume increases it is likely that the geometry (primarily lane and shoulder width) improves.

At this early stage of RISA development, it is difficult to determine average road characteristics that apply to the accident rates. For practical purposes RISA conservatively assumes that the Manual rates apply to roads with:

- adequate clear zones with no hazards within 6m of edge of seal;
- curves with design speeds within the route's speed environment; and
- centrelines, edge lines, and edge marker posts.

As more roads are assessed the true characteristics will become evident and RISA will be revised to suit.

[4] Transit New Zealand, *State Highway Control Manual Issue 3,* Transit New Zealand, Wellington, October 1999.
[5] Transfund New Zealand, *Project Evaluation Manual,* Transfund New Zealand, Wellington, 1999.
[6] Transit New Zealand, *Draft State Highway Geometric Design Manual,* Accessed from http://www.transit.govt.nz, Dec 2000.

The road type factor is shown in Table 3 and reflects the higher accident rates for low geometric standards. Inherent in this factor is that the road type baseline of one has 3.5 metre lanes, 1.5 metre shoulders, and a traffic volume of over 4000 vehicles per day.

2.6 TRAFFIC VOLUME FACTOR

This factor scales the risk from a risk per road user to an overall risk to road users. It is directly related to the exposure of risk to the road user, that is the traffic volume. It is well known that as the traffic volume increases the accident rate increases. The traffic volume factor is the traffic volume in vehicles per day divided by 1000.

2.7 TERRAIN TYPE FACTOR

The PEM provides accident rate models for rural mid-blocks. The models are categorised by terrain type, seal width, and traffic volume. The coefficients for the models are shown in Table 4.

Table 4 Rural Mid-block Equation Coefficients (injury acc/10^8 vkt/year)

Traffic Volume (vehicles/day)	Base Seal Width (m) (3.5m lanes)	Terrain Type		
		Level (0 to 3%)	Rolling (>3 to 6%)	Mountainous (>6%)
0-1000	7	17	23	32
1000-4000	8.5	16	20	28
4000+	10	12	18	24

Factors for terrain were developed from ratios of the above coefficients. The road type factor allows for the difference between the rows in Table 4 so the ratios were relative to the coefficients for level terrain, for each road type. The traffic volume and seal width characteristics are the same as the road type characteristics in Table 3. The terrain baseline is ‘level’ as shown in that column of Table 5.

Table 5 Terrain Type Factors (dimensionless)

Road Type	Terrain Type		
	Level (0 to 3%)	Rolling (>3 to 6%)	Mountainous (>6%)
Low Volume Rural	1	1.4	1.9
Medium Volume Rural	1	1.3	1.8
High Volume Rural	1	1.5	2

The above context factors, road type, terrain, and volume, allow comparisons to be made within a RCA road network to determine which roads have the highest risk to the road user.

2.8 INTERSECTION ASSESSMENT

Intersections are evaluated separately using a similar methodology. The individual items making up the intersection are assessed, and weighted by the leg approach volumes, resulting in the Intersection Risk. This risk is a reflection of the condition of the intersection.

The type of intersection control has a large affect on the potential number of accidents and their severity. To account for this intersection type factors were developed. The PEM reports typical numbers for reported injury accidents at intersections. They are determined by multiplying the number of vehicles entering the intersection per year by a coefficient that varies according to the intersection control type, i.e. linear flow models, as shown in Table 6.

Table 6 Transfund New Zealand PEM Intersection Accident Rates

Control Type	Coefficient	Range of exposure valid (x10^8 vehicles)
Priority Cross	0.124	0.005-0.009
Priority T Intersection	0.068	0.005-0.1
Roundabout (4 leg)	0.115	0.03-0.12
Traffic Signal Cross	0.134	0.03-0.14
Traffic Signal T	0.042	0.03-0.12

Table 7 shows the intersection type factors. They were developed using ratios of the coefficients in Table 6. The factor for uncontrolled intersections was developed from the models in the revision to the PEM, and is twice that of priority T intersections.

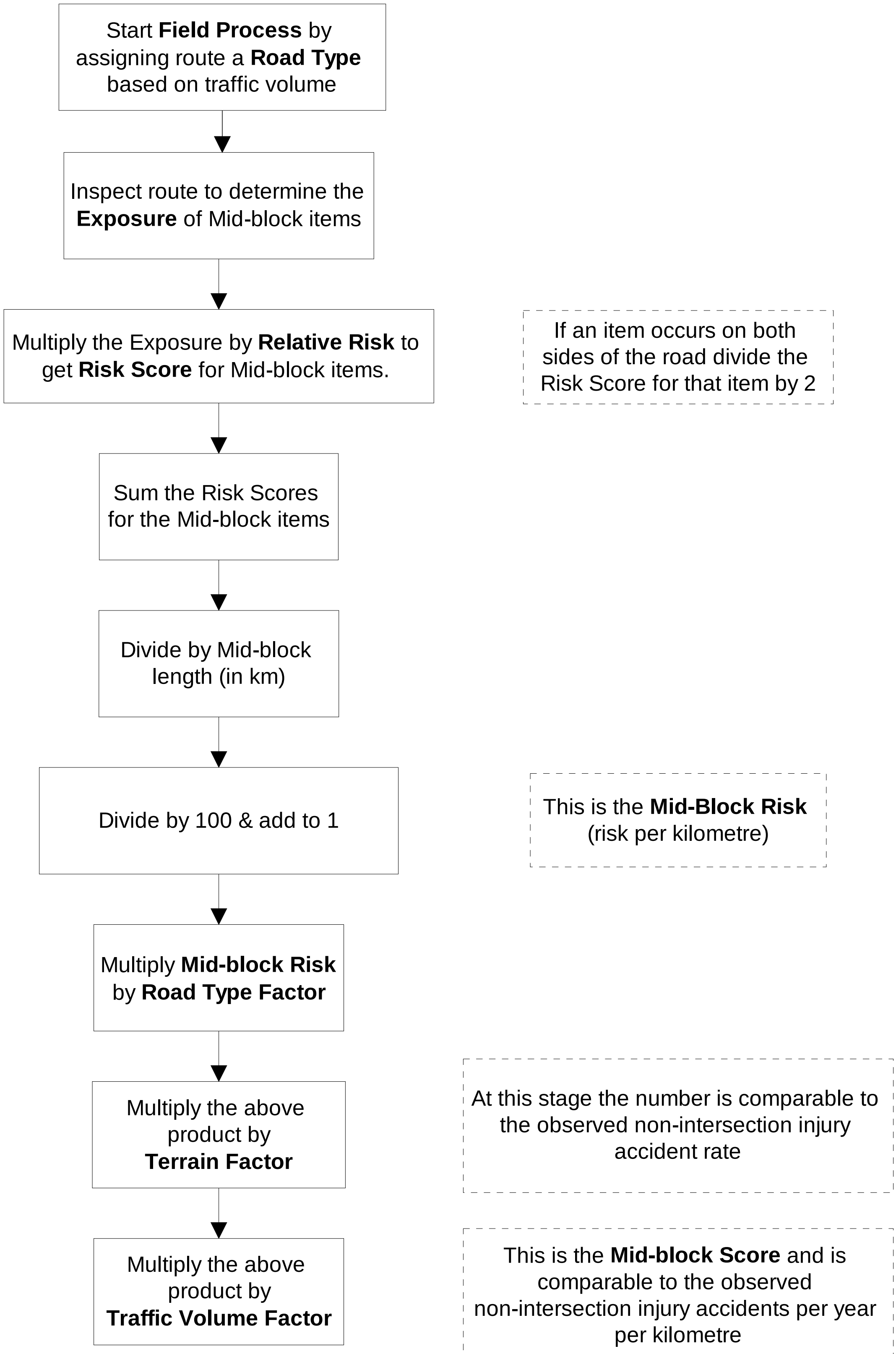
Table 7 Intersection Type Factors (dimensionless)

Intersection Type	Type Factor
Uncontrolled	2.0
Priority Cross	1.8
Priority T	1.0
Roundabout 4 leg	1.7
Traffic Signals – Cross	2.0
Traffic Signals – T	0.6

The Intersection Score is the product of the intersection type factor and the Intersection Risk. The intersection scores are averaged for the route being assessed.

RISA reports intersections separately from mid-blocks. At present it is not practicable to combine the scores for each due to the different way accident rates are predicted for each.

2.9 FLOWCHART OF RISA PROCESS



3 RISA TRIALS

The first trial of RISA was in November 2002 where four routes north of Wellington (test routes) were assessed. Since then, three RCAs have invited RISA teams to assess their road networks, resulting in a total of 35 route assessments.

The assessed route characteristics vary as described by the following tables and figure. They show the routes are predominantly flat with traffic volumes less than 1000 vehicles per day.

Table 8 Assessed routes by Region by Road Type

Road Type	REGION				Total
	Hauraki	Test routes	Waikato	Whakatane	
Low Volume Rural	8		6	6	20
Medium Volume Rural	4	3	3	2	12
High Volume Rural		1		2	3
Total	12	4	9	10	35

Table 9 Assessed routes by Terrain

Terrain	Frequency	Percent
Flat (0-3%)	22	63
Rolling (3-6%)	10	29
Mountainous (>6%)	3	9
Total	35	100

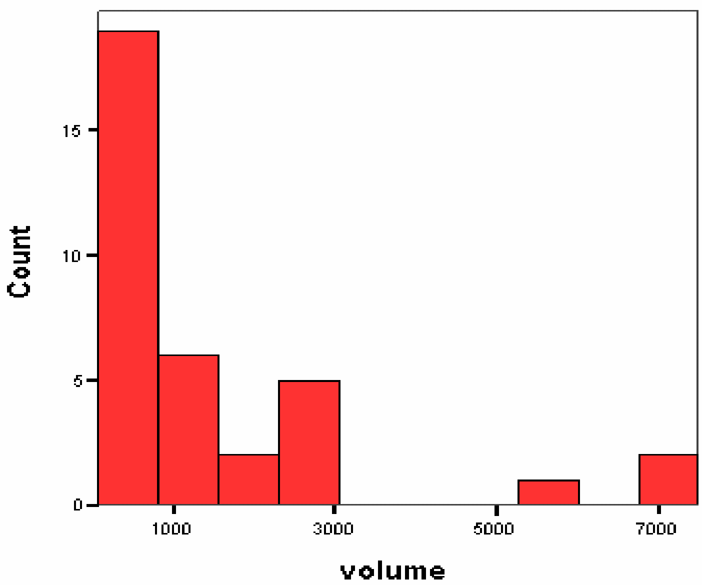


Figure 2 Frequency of assessed routes by Traffic Volume (vehicles/day)

The intersections on the routes were assessed if they had a volume comparable to the main route volume, thus avoiding very low volume side roads that were little more than access ways.

Typical of rural road intersection control priority T's represented over 70% of the intersections assessed.

Table 10 Intersections Assessed by Region and Type

Intersection Type	REGION				Total
	Hauraki	Horowhenua/ Porirua	Waikato	Whakatane	
Uncontrolled	4	4		1	9
Priority T	13	4	13	8	38
Priority Cross	1	3	1		5
Total	18	11	14	9	52

4 VALIDATION

The Risks and Scores developed were compared to the accident histories and assessor subjective ratings of the assessed routes to evaluate RISA.

The purpose of the assessor subjective ratings was to provide a 'sanity check' on the magnitude of numbers developed by RISA. They were completed once the exposures had been recorded for all the mid-block and intersection items. Each assessor was asked to rate the route in terms of road user safety on a scale as shown in Figure 3.

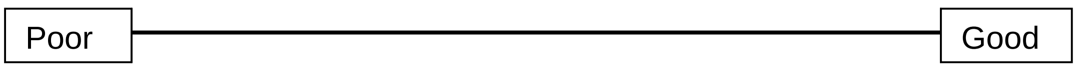


Figure 3 Subjective rating scale

The assessor ratings were converted to a number from zero to ten, zero being 'Poor', ten being 'Good'. The averages of which for each route were then correlated to the accident histories for the routes.

4.1 ACCIDENT HISTORY

To determine observed accident rates, the New Zealand accident database maintained by the Land Transport Safety Authority (LTSA) was interrogated. The coordinates of the route and the coordinates of the accidents were compared to ensure only accidents that occurred within the assessed routes were selected.

RISA is purely an assessment of road infrastructure items and as such certain accident types were excluded from the selection, for example accidents with cause codes or hit object codes relating to the driver. The accidents with the following cause codes were excluded:

- General person, intentional or criminal (510-519)

- Vehicles, load (680-689)
- Vehicles, miscellaneous vehicle (690-699)
- Miscellaneous, animals (910-919)
- Miscellaneous, suicide (996)
- Hit objects, driven or accompanied animals (A)
- Hit objects, stray or wild animal (W)
- Hit objects, objects thrown at or dropped on vehicles (Y)

Timeframes selected for accident history were initially based on industry recommendations of 5 years for sites with traffic volumes greater than 1000 vehicles per day and 10 years for sites with traffic volumes less than 1000 vehicles per day. Where the route infrastructure was known to have not changed a 10-year or 23-year accident history was used, dependent on accident numbers.

Another condition on determining the appropriate accident history timeframe was the confidence limits for site accident rates. The PEM provides 90% confidence intervals for the mean of a Poisson process for a range of accident histories. This data was used to check the reliability of routes with very low accident numbers. In such cases the confidence interval was very large indicating that comparing the associated rates with RISA scores would be tenuous.

To develop the number of accidents into accident rates appropriate traffic volumes needed to be determined. The traffic volume at the median year of the accident history was used. This was back calculated from the current traffic volume using the PEM regional traffic volume growth rates.

4.2 ACCIDENT HISTORY VALIDATION RESULTS

Mid-block assessments

To test the RISA procedure comparisons were made between the scores and accident numbers. The Mid-Block Score is the Mid-Block Risk, in risk/km, multiplied by the road type and terrain factors, both dimensionless, and the volume factor, a measure of the number of vehicles using the route. It therefore is equivalent in units to the observed number of accidents per year. In addition, the RISA Risks and Scores are developed from non-intersection injury accident rates making the correlation in Figure 4 possible.

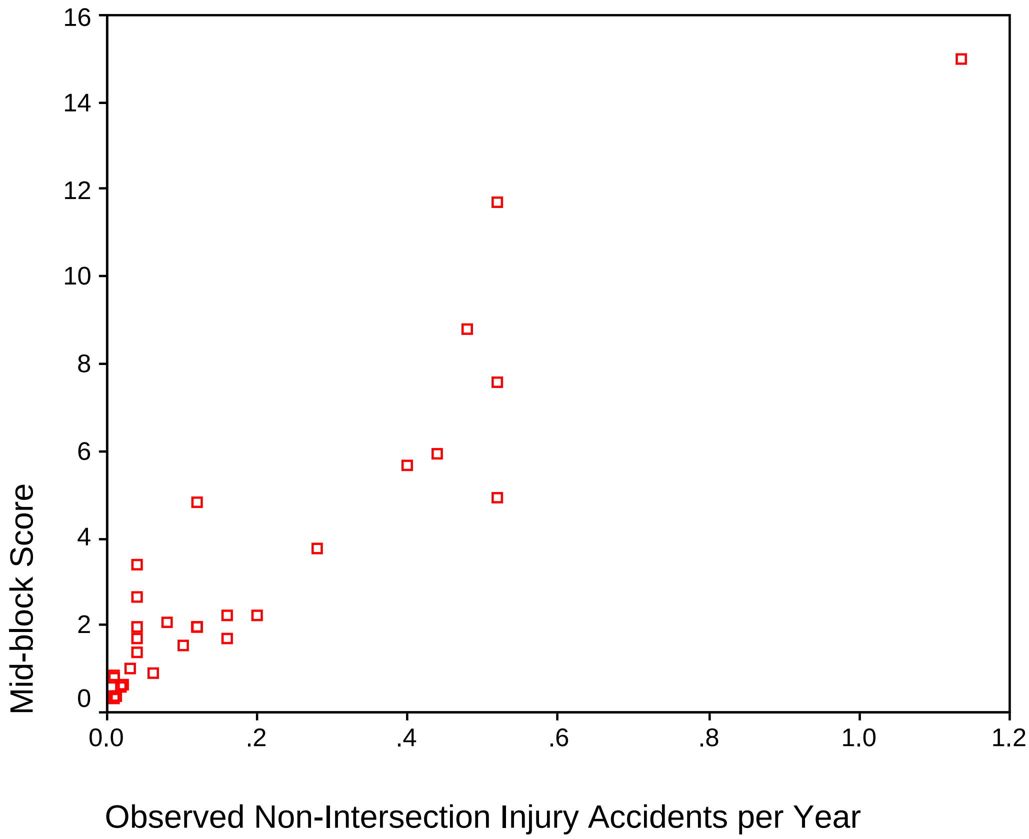


Figure 4 Correlation of Score and Accidents

The above correlation is highly significant ($t_{1,29}$=14.0 (P<0.000), where $t_{critical}$=3.569), with 87% of the variation in the observed number of accidents explained by the Mid-Block Score. This means that the strong relationship between score and accidents had less than 0.1% chance of occurring by accident.

However from Figure 4 it is likely that some extreme values or outliers may have an extraordinary impact on this relationship. An analysis of the Cook's Distances identified three such cases. When these values were excluded from the analysis the resulting relationship was still highly significant ($t_{1,27}$=10.4 (P<0.000), where $t_{critical}$=3.690) and the Mid-Block Score explained 80% of the variation in the observed number of accidents.

Subsequent investigations showed that the bulk of the above variation explained is attributable to the traffic volume factor and road type factor.

The Mid-Block Risk (risk/km) is the combination of the assessments for the three mid-block themes; cross section, alignment, and surface. The variation in the numbers for the three themes is typically small as can be seen in Table 11. These numbers are also typically small compared to the factors that are applied. This supports the RISA method of presenting two separate indicators, the Mid-Block Risk and the Mid-Block Score, as the factors tend to swamp the Risk. This separate reporting allows RCAs to differentiate between those roads that may be of high risk due to where they are, for example hilly windy arterials, and those that have a high risk because of the lack of beneficial safety items.

Table 11 Descriptive Statistics for Mid-block themes

Theme	Number	Range	Minimum	Maximum	Mean
Cross Section	35	0.46	0.98	1.44	1.19
Alignment	35	0.34	0.95	1.29	1.07
Surface	35	0.03	1.00	1.04	1.01
Mid-Block Risk	35	0.60	1.00	1.60	1.26

Intersection Assessments

The Intersection Scores were averaged for each route and then compared to the number of intersection accidents on each route. Of the 28 routes where intersections were assessed, 11 had intersection accidents. Due to these low numbers the comparison provided little insight to the validity of the Intersection Scores.

4.3 SUBJECTIVE RATING VALIDATION RESULTS

To determine whether RISA is any better at predicting accident histories than SAER, subjective ratings of the routes assessed were compared to observed total (including intersection) accident rates. There is no significant relationship between the two. There is a relationship between them but it is very weak and it is most likely that it occurred by chance. However, because at present we only have a sample of 32 routes as we collect more data the significance may change.

5 CONCLUSIONS

We are developing a more objective approach to assess the safety of existing roads. This approach is based on known accident relationships. The results of which provide indicators that allow:

- Assessment of the provision of safety for a given asset; and
- Assessment of the provision of safety overall

Several trials of the more objective method, RISA, and subsequent analysis shows that RISA is performing better than SAER in terms of predicting observed accident rate. This is encouraging as the number of routes assessed is very small and has tended to focus on roads with low traffic volume. To confirm correlations with observed accident histories, it is recommended that several high volume roads be assessed.

An analysis of the variables comprising the RISA safety indicators found that the method tends to rely on traffic volume to predict observed accident histories. This gives support to the two-stage methodology of reporting numbers with and without factors for the context of the route. As more RISAs are undertaken the underlying effects of all factors will become clearer.

DISCLAIMER

The views expressed in this paper are those of the author and are not necessarily those of Opus International Consultants or Transfund New Zealand.

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